Preface

The beginnings of the technique of knitting are lost in antiquity. The principles of hand knitting as a fabric-forming process appear to have been known for centuries. In prehistoric times, nets were made with a type of knitting stitch. Mechanization of the process, however, occurred much later than the development of the weaving loom. A curate, the Rev. William Lee of England, is generally credited with inventing the first knitting machine, in 1589. This machine could knit stockings; equipment like it was used substantially unchanged for about 200 years. By the end of the 18th century, the rotary frame and warp frame had appeared; mechanical circular knitting was invented around 1816. A power-driven machine capable of shaping garments as they were being knitted was invented by William Cotton in 1869's, and this development made possible full-fashioned knit apparel. The warp knitting machine was invented also in the 1860's.

From these beginnings has arisen an important sector of modern textile industries the world over, whose growth in the past decade has been nothing short of phenomenal.

This report will attempt to set forth and analyze these developments and to evaluate cotton's future role in this important segment of the textile industry in Western Europe.

Contents

KNITS IN WESTERN EUROPE - THEIR IMPACT ON COTTON

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SUMMARY

Over the past 10 to 12 years, knitgoods have constituted an ever-increasing portion of total textile production in Western Europe.

Prior to the 1960's, the knitgoods industry of Western Europe largely produced finished garments, whereas in the recent past it has put greater emphasis on the production of fabrics. Although a substantial portion of the knitting industry still produces traditional items—sweaters, stockings, socks, gloves, and underwear—the character of the industry has changed dramatically. In addition, some textile firms whose traditional business has been solely in woven goods have added knitting equipment and expanded into the production of knit fabrics.

The most important single change occurring in knits has been the development of knit fabrics of varied characteristics suitable for cut and sewn apparel, particularly men's and women's outerwear, which had formerly been made almost exclusively of woven fabrics. This phenomenon rested upon the parallel improvement of knitting equipment and manmade fiber yarns of all types, particularly textured yarns. A serious problem from the standpoint of cotton interests is that, for a number of reasons, cotton has not shared in the growth of knits. Moreover, some of the major end-use markets for both cotton and wool have been eroded by knit products of manmade fibers.

The 11 years, 1961 to 1971 inclusive, have been a period of active growth wherein, based on yarn consumption, the knitting industries of Western Europe have expanded more than 100 percent. The increase in several countries has been more than double the Western European average. In total, Western Europe is a net exporter of knit textiles, but imports of knitgoods have expanded rapidly, beginning about 1970. The situation varies greatly by country. A very substantial portion of Italian knitgoods production has been directed to the export market for some years.

A number of factors have contributed to the phenomenal growth of knits. Manmade fiber producers through their research and development activities and their cooperation with and influence on knitting machinery producers have contributed substantially to this growth. They have also taken an active role working with knitters and apparel manufacturers to extend the use of manmade fibers in knits and have promoted manmade fiber knitgoods at the consumer level.

Recognizing the challenge to cotton consumption arising from the growth of knits mainly of manmade fibers, the International Institute for Cotton (IIC)[1] has directed an increased proportion of its research and development funds into overcoming the problems confronting cotton mainly in the knit outerwear market. It has fostered research on new types of cotton yarns and treatments and techniques to deal with shrinkage and dimensional stability of cotton fabrics. In addition, the IIC has placed emphasis on promotion of cotton knit products in Western European program countries.

Traditionally utilized for knit items such as socks, sport shirts, and underwear, regular cotton yarns can be processed readily on practically all types of equipment other than tricot type warp knitting machines. However, they have a number of technical disadvantages when processed on some types of knit equipment. For these, cotton yarns must be pliable, elastic, extra fine, and strong; as a consequence, their cost may be greater than alternative manmade fiber yarns that can be used.

While it is difficult to make cost comparisons between knit and woven end-products, it appears that there is no overwhelming cost advantage to either, and that the choice between them along the chain of distribution will turn on other economic considerations and on fashion elements.

Although the growth of knits has been nothing short of phenomenal, there continue to be many problems in their production and use. It is likely that manmade fiber producers, knitters, and apparel makers will continue to try to work out these problems and continue to push production and consumption of knits to even higher levels.

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[1]The International Institute for Cotton was founded in 1966 to increase consumption of raw cotton and cotton products through utilization research, market research, sales promotion, education, and public relations. Countries representing in 1971-72 almost 60 percent of the production and about 40 percent of the exports of cotton of the non-Communist world are members. These countries are: Brazil, Greece, India, Mexico, Spain, Tanzania, Uganda, and the United States.

It appears, however, that the dynamic growth of knits in Western Europe may have already reached its peak. Some voices still predict continued rapid growth in knitgoods, of manmade fibers, particularly. But the growth rate has already turned down and at least in some major items such as women's double knit dresses and suits, consumer acceptance is beginning to diminish.

Other voices maintain that the challenge that knitgoods have presented to the weaving mill can be met. It would be hoped that the challenge of manmade fibers to cotton in knit textiles can be overcome in view of the dedication with which cotton interests are attempting to meet it, especially if this dedication can be matched with an appropriate budget.

CHARACTERISTICS OF KNITTING INDUSTRY

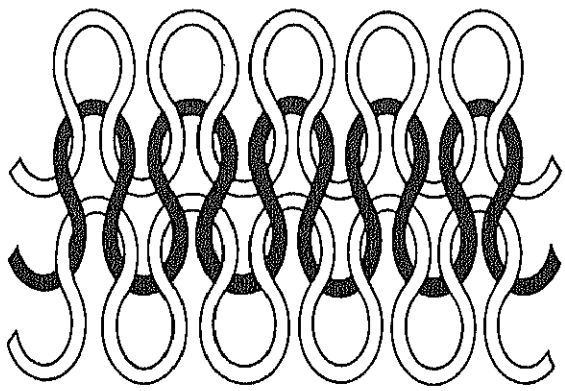
Types of knits

What is a knit, and how does it differ from a woven product?

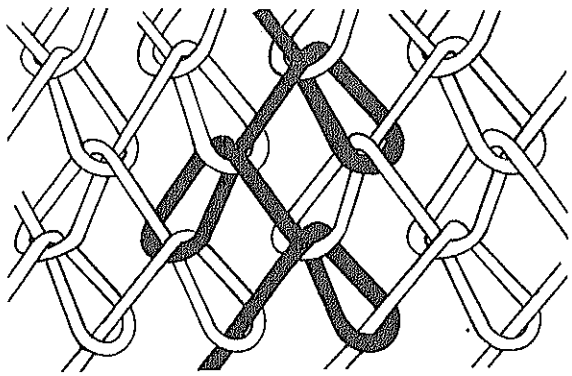
In a woven fabric, two systems of yarn interlace at right angles. Warps run lengthwise, and fillings run crosswise. Depending on the loom capability, yarns of practically any type can be used. Woven fabrics are resistant to stretching, unless stretch yarns are used.

Knits, on the other hand, are characterized by an interlocking series of loops of one or more yarns. The basic types of knit goods are: (1) Weft knits, either single or double, which are made on either circular or flat machines, and (2) warp knits, of which there are several kinds, the most important being tricot, Raschel, and simplex.

Both of these major types of knit goods have different attributes and are adaptable for specific end-uses. A knitter utilizes a variety of equipment, yarns, and stitches to produce a wide range of products. Except for some Raschel types, knits are characterized by elasticity, i.e., stretch and recovery. Most knits are also characterized by interstices (open spaces) in the structure; it takes more yarn to get the same cover in knit structures than in woven goods. Fabrics, which have experienced the greatest growth, are produced on both weft knitting and warp knitting machines.



The yarns in a weft knit run across the fabric in the filling direction.



The yarns in a warp knit run lengthwise.

Development of the industry

The knitting sector of the textile industry in Western Europe and elsewhere has traditionally been a maker of garments. There have been some large knitting firms but, for the most part, knitting firms have been small and medium-size companies that purchased yarn and sold finished hosiery, cotton knit underwear (including sleepwear), fully fashioned cashmere or wool sweaters, gloves, and other knit consumer products assured of a more or less stable, but not rapidly growing, market. Conservatism was the basic characteristic of the industry, devoid of the pressures of fashion impact.

Beginning about 1960, however, substantial changes occurred with respect to both industry

structure and products manufactured. The major development has been the rapid rise in the production of knit fabric for cut-and-sewn apparel manufacture, made possible by the development of double knit fabrics suitable for outerwear. These fabrics first appeared in Western Europe in the early 1950's and were made of wool. The major impetus for the fabrics came with the availability of textured manmade fiber yarn, specifically acetate and polyester.

Concurrently, there was some decline in the relative importance of fully fashioned knitgoods. The popularity of nylon seamless hosiery, which is thermoset to shape or left unboarded (unshaped), largely replaced seamed hosiery. The somewhat later development of pantyhose and women's outerwear styles that fostered their use also contributed to the changed character of the business. Although traditional knitters still turn out traditional products, these developments and others have in the recent past subjected knitgoods producers to the vagaries of fashion trends and caused a revolution in the industry.

In 1970, it was estimated that there were over 538,500 knitting machines of various types in place in the world, most of them in Western Europe. About a third of the world total was in West Germany. Measured by output or by yarn consumption, West Germany also has the distinction of having the largest knitting industry in Western Europe followed by the United Kingdom, Italy, and France. Compared with these four, the knitting industries of other Western European countries are small, although some of these, particularly in Spain and Portugal, have shown phenomenal growth.

In the same year, the world's knitting equipment by type was as follows:

	1,000 machines
Double knit	28.0
Single knit (including full-fashioned machines with one needle bar)	100.0
Raschel	11.0
Tricot	28.0
Seamless hose	200.0
Half hose	130.0
High pile	1.5
Other circular knit	40.0

Source: *Modern Textiles,* April 1971, Rayon Publishing Corp., New York City.

Later data on the numbers of knitting machines in place are not available; however, there is probably an increase in some types—particularly double knit, Raschel, tricot, and high pile—and the replacement of older by more modern equipment.

Between 1960 and 1971, production of knitgoods in Western Europe expanded over 9.4 percent annually, while production of woven goods has been more or less stagnant. However, there was probably not this great a difference at the consumer level because of the high incidence of woven goods imports from non-European sources during that period.

Characteristics by country

The size and character of the knitting industries and the rapidity with which they are adapting to these changes vary from country to country. The knit boom in Western Europe started in West Germany around the early 1960's. The industries in France, Spain, and Italy caught the fever somewhat later, and these countries are still experiencing rapid growth, while in West Germany production increases have dropped to a lower growth rate. In Italy, where there were 9,550 active firms in 1971, a small percentage of the firms accounted for a very large portion of total production. About 80 percent of the firms had fewer than 10 employees. Cottage production is a characteristic of the Italian knit industry. Although Italy's expansion in the knit arena came at a later stage than other major West European producers, it has captured a large export market with its low prices and/or high styles. Belgian and French firms are still mainly garment producers.

In the United Kingdom, there are about 800 manufacturing units, of which 70 percent employ less than 200 people. A major manmade fiber producer in the United Kingdom owns about 35 percent of the weft machinery and about 70 percent of the warp knit equipment in the country. Although there are some spinner-weavers entering knitgoods production, there remain many small producers undergoing considerable pressures to integrate into larger, more efficient units.

The industry in the Netherlands is relatively small. It has its traditional knitters, but one Dutch weaver has converted completely to knitgoods production while another has gone strongly into warp knits, but continues to produce woven fabric.

West Germany had been the leading producer of fabrics for many years but lost this distinction in 1967 when it was overtaken by the United Kingdom. West

Germany continues to be the largest producer of underwear, with the United Kingdom, Italy, and France also important producers. Italy has been the outstanding producer of outerwear, overtaking the West German volume in 1967.

Within these basic national differences, some general trends emerge. Although some small and medium-size family firms have continued to operate in the same old way, others are meeting the new conditions by a variety of methods. Some have formed buying groups to purchase yarn, some have consolidated into large more diversified firms, some have tried to meet the challenge by changing their traditional production and sales systems. Among these innovations, not the least important is the installation of new, efficient, flexible production equipment. In addition, large weaving companies have entered knit fabric production to counteract loss of sales in woven fabrics. In some countries, manmade fiber producers, through corporate ties or financing arrangements with knitting companies and with knitting machinery manufacturers, have exerted considerable influence on the knitting industry and its choice of fibers.

Products of knitgoods industry

The major product classifications of the knitgoods industry are underwear, outerwear, stockings and related products, fabrics, products for industrial and household use, and apparel. Within these categories are hosiery, socks, gloves, sleepwear, infant wear, swim suits, hats and caps, tights, pantyhose and body stockings, and other specialty items. Also made on knitting equipment are lace, powernet and other fabrics used for foundation garments and brassieres, curtain fabrics, fishnets, thermal underwear fabrics, crochet fabrics, bonding fabrics, etc. Production of each of the major categories has expanded in the past decade, but the greatest growth has occurred in fabrics, for which production expanded almost 300 percent between 1960 and 1970.

GROWTH OF KNITS

The rapid increase in volume and importance of knitting in the textile industry has been so great in Western Europe since the early 1960's that it has been termed an "explosion." Based on weight, knitgoods have risen from about 10 percent of all textiles produced in 1960 to 18 percent in 1970 and projections for 1985 place the proportion between 30 and 50 percent. Statistics have not caught up with the revolution in the industry, but, regardless of the data used, it is apparent that numbers of machines have increased, yarn consumption has increased, output has zoomed, and the proportion of knitgoods produced in comparison with woven goods has risen dramatically.

Comparability of data between countries is somewhat difficult. In some countries, weavers producing knitgoods report production and other data to woven goods industry associations, rather than the knitgoods industry associations. Statistics on knit yarn consumption or knitgoods production may not be uniformly included; consequently, the data may not be entirely valid or comparable, especially for the early years. With this caveat, data on yarn consumption by knitting industries, published by the Organization for Economic Cooperation and Development and by the International Secretariat of the Knitting Industries, are shown in table 1.

Yarn consumption in Western Europe rose over 100 percent in the 11 years between 1961 and 1971, an average annual increase of 9.4 percent. In total, the increase in yarn consumption has varied from practically nil between 1965 and 1966 to more than 15 percent between the years 1962 and 1963 and between 1968 and 1969. While below the 11-year average, the growth rate at 5.5 percent continued between 1970 and 1971, the latest year for which data are available.

Measured by yarn consumption, the increase in knitgoods production has been substantial in all countries except Norway. In the EC countries, it almost doubled in the 11-year period under review. While West Germany remains the largest knitgoods industry in Western Europe and the world, its growth of 95.2 percent has been topped by Italy with a growth of 203.3 percent. Some of the smaller knitgoods producing nations, notably Switzerland and Spain, also have high growth rates.

There are little other data to compare knitgoods output among countries except fabric production statistics, which must be evaluated in the light of knit products that are manufactured directly, such as fully fashioned items. In Western Europe, fabric production has expanded from just under 180 million pounds in 1960 to 659.4 million in 1970. Data for 1971 are incomplete but where available the growth appears to be continuing.

Table 1.—Yarn consumption by the knitting industries of Western Europe, 1961-71.

Country	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	Increase 1961-71
	Mil. lb.	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Percent*
Belgium	29.5	32.0	39.9	38.8	37.7	39.9	36.2	37.9	41.2	42.5	46.7	58.3
Denmark	11.3	13.4	14.8	16.8	18.1	18.5	18.5	19.6	19.6	19.6	19.6	73.5
France	119.3	129.0	150.1	156.8	143.1	160.5	153.2	158.3	197.1	196.5	215.4	80.6
Germany,West	205.9	223.1	240.5	268.3	284.6	271.8	261.5	305.1	347.0	363.1	402.0	95.2
Ireland	7.5	7.9	8.2	9.5	9.5	9.0	10.6	8.4	(1)	(2)8.5	12.5	66.7
Italy	107.6	117.0	145.1	151.2	197.5	186.3	192.9	211.0	253.5	286.6	326.3	203.3
Netherlands	33.5	35.3	42.8	49.4	48.5	57.1	54.4	61.5	66.2	62.8	63.0	88.1
United Kingdom	170.4	171.7	211.2	224.0	230.8	236.8	236.3	226.4	238.7	260.8	280.2	64.4
Total Economic Community	685.0	729.4	852.6	914.8	969.8	979.9	963.6	1028.2	1163.6	1240.4	1365.7	99.4
Austria	17.7	18.5	20.9	23.6	22.7	25.4	21.8	25.1	24.9	(2)24.9	24.9	40.7
Finland	(1)	(1)	(1)	17.4	16.3	19.4	19.8	20.3	23.6	25.4	26.7	(1)
Greece	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	20.3	(1)	(1)	(1)
Norway	11.0	11.3	13.2	11.7	9.7	9.7	11.0	10.4	10.6	10.7	11.5	4.5
Portugal	10.1	11.3	12.1	13.0	31.8	24.2	24.3	(1)	(1)	(1)	(1)	(1)
Spain	15.4	13.9	19.2	16.5	52.0	46.1	53.4	52.9	70.5	79.0	76.5	396.7
Sweden	18.2	19.8	21.4	22.0	19.9	18.3	20.1	21.2	22.3	22.5	28.3	53.0
Switzerland	10.4	10.8	11.2	15.0	15.2	16.8	22.0	24.0	25.4	28.2	30.9	197.1
Total Other Western Europe	83.1	85.6	98.0	119.2	167.6	159.9	172.4	153.9	197.6	190.7	198.8	139.2
Total Western Europe	768.1	815.0	950.6	1,034.0	1,137.4	1,139.8	1,136.0	1,182.1	1,360.9	1,431.1	1,564.5	103.7

[1] Not available. [2] Estimate.

Source: Reports of Organization for Economic Cooperation and Development (OECD) and Secretariat International des Industries de la Maille, Paris.

The impact on the weaving sector of the textile industry from the knitgoods explosion is evident in the accompanying charts. As knitgoods production expanded sharply between 1963 and 1967, production of woven goods dropped rather precipitously, but has leveled off somewhat since then. It is evident, however, that the growth in fabric production in Western Europe has accrued to knitgoods rather than to woven. In the United Kingdom, an index of textile production (based on 1958=100) shows knitting production standing at 171 in 1968 and weaving of cotton and manmade fibers at 65, including the processing of filament yarn. In West Germany the impact of the knitgoods explosion on woven goods production is reflected in information on production equipment. In the 2-year period 1967 to 1969 the number of knitting machines increased from 149,000 to 176,000, while cotton looms were reduced from 64,000 to 58,000. In 1960 the knitting industry accounted for 12.6 percent of the yarn consumed in West Germany, while by 1970 it accounted for 20.3 percent of total.

Trade in knitgoods has significance in some Western European countries. The major countries of Western Europe export in aggregate value more knit textile products than they import. Italy is by far the largest exporter. Most of Italy's exports consist of outerwear—the famous "Italian knits," which have maintained a fashion image for a number of years. Italy's exports are about 75 percent greater in value than the exports of West Germany with a much larger industry. France and Great Britain also have a large export market for outerwear and fabrics. On the other hand, despite substantial exports, West Germany is a very large net importer of knitgoods, followed by the Netherlands, France, and the United Kingdom, in descending order of value.

This report deals only with the knitgoods industries of Western Europe even though imports add to the volume of knitgoods available to consumers in countries with negative trade balances and subtract from the volume in those with greater exports than imports.

Table 2.—Knitted fabric production in Western Europe, 1960, 1970, 1971

Country	1960	1970	1971
	Mil. lb.	*Mil lb.*	*Mil. lb.*
Belgium	16.6	29.4	(1)
Denmark	4.4	15.7	(1)
France	16.7	64.4	64.9
Germany West	46.8	154.6	162.7
Ireland	(1)	(1)	(1)
Italy	11.0	40.1	(1)
Netherlands	4.9	34.2	35.3
United Kingdom	39.0	186.3	[2] 197.7
Total Economic Community	139.4	524.7	(1)
Austria	14.5	31.1	(1)
Finland	1.5	8.0	7.9
Greece	(1)	(1)	(1)
Norway	0.2	2.4	2.7
Portugal	8.6	32.8	(1)
Spain	9.6	45.9	(1)
Sweden	2.9	14.5	12.6
Switzerland	(1)	(1)	9.3
Total other Western Europe	37.3	134.7	(1)
Total Western Europe	176.7	659.4	(1)

[1] Not available. [2] From Department of Trade and Industry.

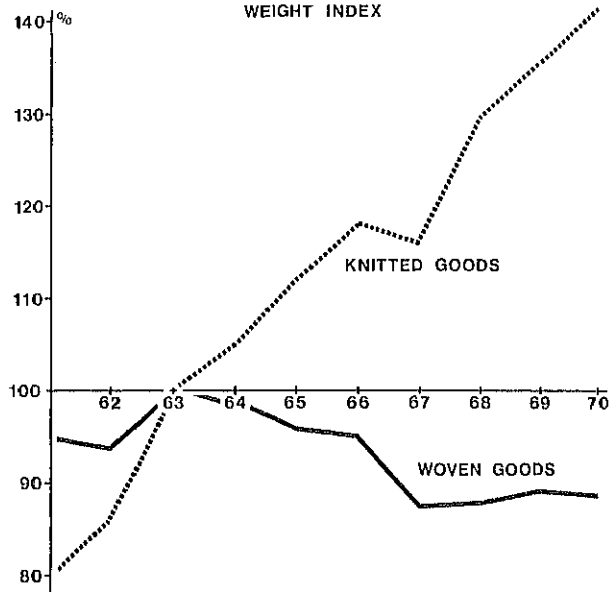
Source: Study on Textiles, General Agreement on Tariffs and Trade, Geneva. December 1972.

Table 3.—Western European trade in knitgoods of all types, 1971

Country	Imports	Exports
	Mil. dol.	*Mil. dol.*
Austria	59.4	68.8
Belgium	145.4	133.4
Denmark	58.5	75.4
Finland	33.7	48.0
France	236.6	284.1
Germany, West	721.8	474.3
Great Britain	199.1	290.7
Ireland	30.0	24.3
Italy	56.2	826.1
Norway	79.0	11.9
Netherlands	271.9	102.6
Portugal	8.0	35.3
Spain	8.9	23.9
Sweden	149.5	58.1
Switzerland	168.0	60.4
Total above countries	2,226.0	2,517.3

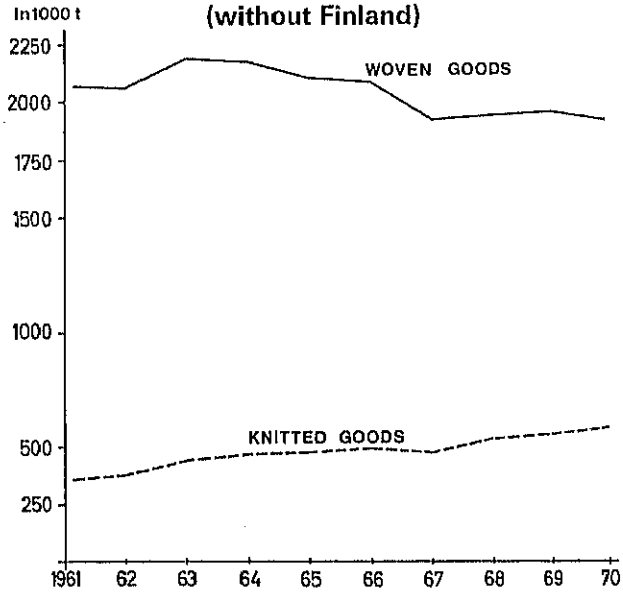
Source: "Statistiques 1971", Secretariat International des Industries de la Maille, Paris.

Production of Standard Woven Goods and Knitted Goods in the EEC and EFTA, 1963=100



Source: "Market and Cost Trends for Woven and Knitted Goods," address by Dr. Gerhard Brockel, Manager Product Planning, Textile Machinery Division, Gebruder Sulzer AG., Winterthur, Switzerland, at the General Assembly of the International Federation of Cotton and Allied Textile Industries (IFCATI), Spain, October 1971.

Production of (Standard-) Woven and Knitted Goods in the EEC + EFTA (without Finland)



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Yarn consumption by fiber type

Cotton has not shared proportionately in the phenomenal growth of the knitting industry. The major advance has been by noncellulosic manmade fiber yarns which compete not only with cotton but with wool as well as other manmade fibers and silk. For some end-uses, for example, women's hosiery and pantyhose, noncellulosic manmade fibers compete with neither cotton nor wool. A simple comparison between the total volume of manmade fibers and cotton consumed in knitgoods actually overstates the impact of manmade fibers on cotton markets. However, such a comparison is useful to show the difference in growth rates between the fibers used in knitgoods.

In 1960, yarn consumption by Western European knitters totaled just over 759 million pounds; by 1971 it had reached 1.56 billion pounds, an increase of over 100 percent. Cotton constituted about 40 percent of the 1960 total, but only about 23 percent of the 1971 total. On the other hand, the use of noncellulosic manmade fibers grew from under 16 percent of the 1960 total to 55 percent of the larger 1971 aggregate. While consumption of cotton yarns increased 17 percent from 302 million pounds to 354 million pounds between 1960 and 1971, consumption of noncellulosic fiber yarns increased over 600 percent from 121 million to 856 million pounds in the same period.

There are substantial differences between countries in the growth rate between fibers consumed in knitgoods. Cotton was the major knitting yarn in the Netherlands, constituting over 53 percent of total in 1960, while by 1971 cotton was about one-third of total. Wool was also a loser, but manmade fiber yarn, particularly noncellulosic fialment, rose from about 12 percent to just over 50 percent in the same 11-year period. In both West Germany and France, cotton constituted about 47 percent of total knitting yarn in 1960, and only about 25 percent 11 years later. In these 2 years, (1960 and 1971), wool dropped from over 25 percent to just over 15 percent in West Germany; by 1971, noncellulosic fiber yarns constituted 52 percent of total. In France, wool dropped from 25 percent to 13 percent in the same period; and by 1971, noncellulosic fiber yarns constituted 57 percent. In Belgium, cotton dropped from 41 percent of total yarns in 1960 to 19 percent in 1971, while wool declined from 42 percent to 27 percent, and noncellulosics rose from 11 percent to 48 percent.

The United Kingdom, a major producer of manmade fiber, shows the worst position for cotton, explainable to a substantial degree by the ownership of much of the knitting capacity by major manmade fiber producers. Cotton constituted about 35 percent of total yarns consumed in knitgoods in 1960 while in 1971 cotton's share of total had fallen to only 11 percent! Again, wool was a major loser also, dropping from 36 percent to 15 percent. Manmade fibers of all types totaled 70 percent, a proportion not reached elsewhere; of this, 64 percent were noncellulosics and 6 percent cellulosics.

From changes already occurring, one could expect that the large manmade fiber industries in Western Europen countries will continue to try to push increasing quantities of manmade into their knitting industries.

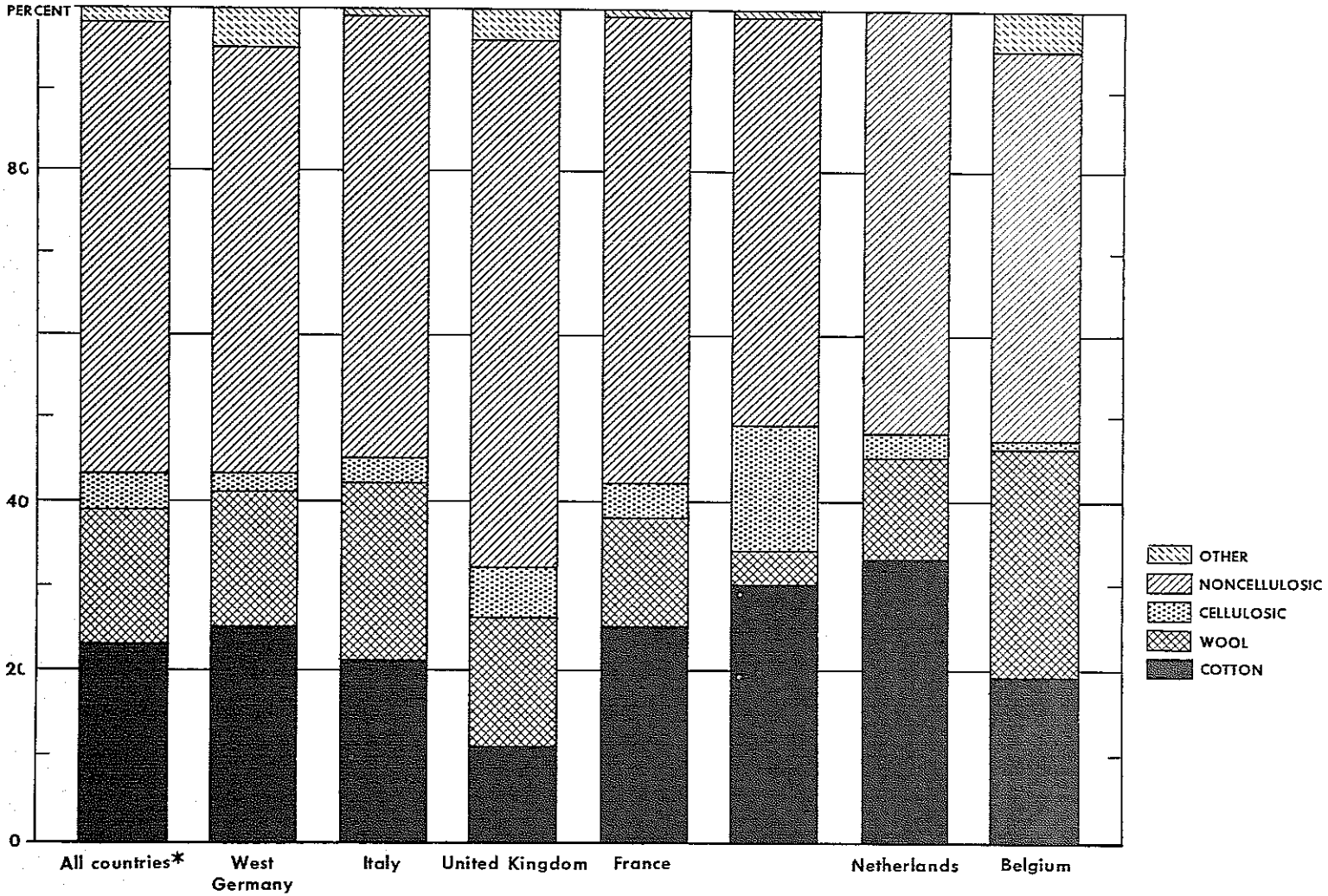
Factors fostering growth of knits

The rapid rise in the growth of knitgoods suggests that unusual factors have been in this sector of the textile market. Perhaps, rather, it is the interaction of a combination of factors that has produced the knit "explosion." The influence of the manmade fiber producers of Europe and the influence of the knitting machinery manufacturers are particularly significant. The various advantages to manufacturers producing and to consumers using knit goods have also been important to their growth. In addition, the emergence in the 1960's of Western Europe as a net importer of woven textiles put great pressures on textile and apparel manufacturers. There was no such comparable pressure from imports of knitgoods; this undoubtedly encouraged expansion into knits.

Manmade fiber producers—There is little doubt that manmade fiber manufacturers have played an important role in fostering the growth of knits. These influences have been both direct and indirect. The policies of manmade fiber producers have been designed to provide outlets for their fiber production, and much of their research and development work is directed to that end. In several countries of Europe, knitting companies are owned entirely or in part by manmade fiber producers, who constantly seek ways to maximize the use of their fibers. If products, such as underwear, cannot be made entirely of manmade fibers, yarns blended with cotton are utilized as a matter of "company policy." In its annual report, a large British manmade fiber company

YARN CONSUMPTION BY FIBER TYPE IN KNITTING INDUSTRIES OF WESTERN EUROPE AND IN SELECTED COUNTRIES

1971



SOURCE: "Statistics 1971", Secretariat International des Industries de la Maille, Paris.

*Includes Western European Countries for which separate data not available.

owning a large portion of the knitting industry in the United Kingdom comments with respect to the relationship in its company of manmade fiber production and textile manfacturing as follows: It "provides an effective channel for the swift commercial implementation of new textile and fiber developments."[2]

An association of manmade fiber producers in Western Europe says, "Weaving is still volume-wise more important than knitting, but the latter has made much progress in recent years largely due to synthetic yarns."[3]

Manmade fiber producers have developed many yarns with special properties designed specifically for knits: new deniers, and new denier per filament yarns, yarns with "dull luster," yarns with new dye variants, yarns which offer increased styling potential, and the like. Brand-name fiber promotion by manmade fiber producers also assists the knitter, as well as the weaver and apparel manufacturer. This has been particularly significant in knitgoods for textured polyester which has a great consumer following as Crimplene, Diolen, Terylene, and Trevira and for acrylic fibers as Dralon, Orlon, etc.

Manmade fiber producers also assist knitters with advertising expenses, labels, travel for "education and training," and other perquisites. According to a leading West European manmade fiber producer, it is easier to influence knitters than weavers, perhaps because of their relative size and characteristically short commitment to a given design or style, as well as their versatility.

Under some circumstances, when launching a new product with the assistance of a manmade fiber producer, a knitter can expect the latter to be a motivating force encouraging sale of his product through promotion and consumer education. If approved from a quality standpoint, a new product submitted by a knitter to a manmade fiber producer will be entitled to advertising funds and labels designating quality control. In fact, this system is quite inbred in Europe. Whether this is a desirable influence is not unanimously agreed. In the United States, a spokesman for the largest U.S. textile manufacturer has attacked the policy by openly declaring that "Fiber producers should stop trying to master-mind merchandising of their customers' products."[4]

This attitude can also be found in some European knitgoods industries, but on the whole, the assistance of manmade fiber producers is welcomed.

Knitting machinery producers.—Manmade fiber producers also put pressures on knit machinery manufacturers, with whom they may or may not have financial connections. In turn, the machinery manufacturers play a role in "creating a world of fashion" at their laboratories, to show knitters the product range of their equipment to encourage maximum sale and use. Modern equipment coupled with a wide variety of yarns create an almost endless possibility of fabric design, and this is exploited to the utmost.

Knitters and apparel manufacturers.—From the standpoint of fabric and apparel manufacturers, the trend to knits has provided an opportunity for profits based on quick turnover. On the average a manufacturer requires 3 months from date of order-taking to complete the manufacturing cycle for knitgoods compared to 6 months for woven goods. Knitters are able to keep stocks to a minimum and to move with rapid and somewhat unpredictable changes in fashion. Knitting has fewer processing and distribution steps than weaving. As a consequence the severity of fluctuations in the textile cycle with its alternate periods of stock accumulations and reduction is minimized. Also, it may be relatively less costly to develop new fabrics with various types of yarns, designs, finishes, etc., because a sample fabric can be made with less preparation and in smaller batches on knitting than on weaving equipment. In addition, it is easier for apparel manufacturers to integrate backward by knitting cloth than to produce their own woven goods which, in order to be economically viable, require a bigger capital investment.

From the standpoint of the cutter, there is an advantage in the use of wide goods, which can be cut with less waste than narrower goods.

Consumers.—An important aspect of the phenomenal growth of knits has been their acceptance by consumers. It has been estimated that the elasticity of consumer demand in the Economic Community for all textiles is 0.8, but that it is 1.3 for knit outerwear and less than 0.8 for underwear. A study made by the Industrial Council for Textiles and Clothing, Brussels, reports that expenditures for clothing in Belgium almost doubled between 1954 and 1968. The portion consisting of knit clothing was about 27 percent of total in 1954 and has risen consistently each year until it represented 37 percent

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[2]Courtaulds Report and Accounts, 1971-72. Alabaster Passmore & Sons Ltd., London and Maidstone 275. United Kingdom.

[3]"Forecast, 1980," Comite International de la Rayonne et des Fibres Synthetiques (CIRFS), Paris.

[4]Ely Callaway, President, Burlington Industries, in speech May 7, 1971, before International Federation of Knitting Technologists.

of total in 1968. Estimates from a different source indicate that in 1970 knits constituted 35 percent of all clothing in West Germany and 20 percent in France.

From the standpoint of end-use qualities, consumers turned to knits for comfort, particularly ease of movement, performance related to wrinkle resistance, versatility, and easy care in laundering. Fashion also played a part. Consumer acceptability is accounted for in part by the youthful revolution against traditional clothing (for example, plain white underwear) and the casual appearance and high style of some knit outerwear. The youth market in the United Kingdom accounts for about one-half of the clothes purchased. The growth of leisure and the related demand for clothes to fit the occasion also contribute to the appeal of knits to the consumer. Outerwear sales are directly related to fashion, and sales of fashion goods are influenced more by style and price than by fiber.

Role of International Institute for Cotton

The International Institute for Cotton (IIC) conducts market and technical research and carries out sales promotion and public relations directed from its Brussels office on behalf of cotton in 13 West European countries.[5] In view of the new importance of knitting in the textile industry over the past decade, IIC has focused attention on a number of cotton's most urgent problems in this segment of the textile market. With respect to cotton knits, research has been undertaken on dimensional stability, elasticity, ease of care, and the development of yarns with special attributes for knitting. Machinery developments that could improve cotton's competitive position are also being given attention. This research is carried on by or under the auspices of the IIC at the Shirley Institute in Manchester, England.

Other organizations and private firms in Western Europe and in the United States are working on problems associated with the use of cotton in knits. If there is conviction that a market for cotton knit end-products is there or can be developed, experimental work in these various problem areas will probably be pushed to conclusion on a profit-making basis.

The IIC is also the major instrument giving impetus to cotton promotion in Western Europe. The activities undertaken in program countries include consumer advertising, merchandising and store promotions in association with leading garment makers, trade press advertising, distribution of display material, fabric services, and other related activities. Under license agreement with knitters the IIC provides a cotton emblem to identify good quality cotton products. The cotton emblem links the products to the consumer benefits of cotton. The emblem can be used only in connection with products made of cotton and identified by a brand name or trade mark.

Cotton emblem of International Institute for Cotton.

MANUFACTURING ASPECTS

Yarns for knitting

There is a great variety of both natural and man-made fiber yarn from which knit products can be and are manufactured; and regardless of the type used, yarns are a substantial cost item in knitgoods. According to D.G.B. Thomas of the Shirley Institute[6] the choice of yarn is always a compromise between

[5]Austria, Belgium, Denmark, Finland, France, West Germany, Italy, Norway, the Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Japan is also a program country.

[6]"SPUN YARNS IN WARP KNITTING; WHAT ARE THE PROSPECTS?" by D. G. B. Thomas, Shirley Institute, Manchester, England, *Textile Month*, August 1971.

the needs of knitting efficiency and availability of the yarn, maximum cost for the finished fabric, and the attainment of attractive design. In other words, yarn count (size) must be coordinated with the characteristics of the machine on which it is to be used, particularly the cut or gauge of the equipment, and the desired properties in end-product.

The economic size of a knitting unit in terms of yarn consumption is smaller than the economic size of a spinning, i.e., yarn producing, unit. Therefore, knitters are generally not yarn spinners. Some large spinner-weavers who have added knitting operations supply their yarn needs for knitting but, in general, knitters buy yarn on the sales yarn market rather than make it. This practice minimizes investment in raw materials and maximizes yarn variety for style merchandise.

Cotton yarns.—As a general rule, cotton knitting yarns must be of better quality with less variation in cross section and more even count than cotton yarns for weaving. Most spun yarns for weft knitting have low twist, which gives a soft hand to the finished product; however, high-twist yarns are required for some types of warp knitting because of the extreme tensions caused by the process. Plied yarns may be used to overcome thin and soft spots found in singles, but plied yarns cost relatively more than singles of the same size. Two or more ends of single yarn running into each guide may also be used to average out weak places. Gasing and waxing are used to overcome the problems associated with fiber entanglement and lint deposition. Sizing provides some additional strength needed for knitting cotton yarns, particularly for warps.

The use of spun yarns for knitting inhibits snagging and reduces the air permeability which is objectionable for some kinds of end-products. Although filament yarns are more efficient to knit and can be run at higher speeds, the use of spun yarns alone or in combination yields a fabric with fewer undesirable properties.

Cotton yarns used for knitting are often made of high grade, long staple cotton which is combed and mercerized. In Europe, Peruvian Tanguis cotton is favored for some types of knit apparel, especially underwear, because it has valuable spinning properties which extend to the finished garment. Users of Peruvian cotton obtain results with carded yarn that compare favorably with combed yarn of other types of cotton. It is stronger than other cottons. Its unusual whiteness permits the garment to be sold "in the grey," thus saving on bleaching costs.

Spun yarns may be used in single jersey, double jersey, and in Raschel and simplex fabrics. Cotton yarns used on tricot machines are almost always combed, since the primary trouble in knitting spun yarn on warp knitting machinery is associated with the hairiness of the fibers and their tendency to cling together.

In addition to the basic carded, combed, and mercerized yarns of cotton, there are specialized types with limited markets, such as core spun with an elastomer or stretch nylon component.

Several recent developments in cotton yarns offer the possibility of their increased use in knitting. One of these is break spun, or open end, yarns invented in Czechoslovakia about 1967. These yarns are now made under license in a number of other countries. Break spun yarns are uniform and freer from knots than conventional ring spun yarn, and provide good cover; they are "crisp" and a bit more "hairy" than conventional yarns. In knitted products, break spun yarns give different handle and elasticity. They average about 20 percent less strength than conventional yarns but have fewer very weak places because of their greater regularity. The strength of break spun yarns is sufficient for circular knitting and for weaving, but not for warp knitting. The relative lower strength of break spun yarn does not necessarily result in weak fabrics. Because of lower labor input, break spun yarns are less expensive to manufacture than ring spun yarns in the lower counts. However, where offered, they are selling at about the same price as conventional yarns. According to the International Institute for Cotton, results look promising for its research on break spun yarns of 100-percent cotton for knitting.

Another yarn development that may advance cotton in knitting is that of twistless yarn, a process still in it infancy. In this system of production, yarns are bleached in roving form, drafted wet, subjected to application of an inactive starch, and crosswound on packages which are steamed for about an hour at 110°C. Conventional spun yarns achieve interfiber cohesion by pressures created by the twist, but the use of conventional spun yarns for circular knitgoods results in a fabric with torque. Knitted and woven fabrics of reasonably close construction made of twistless yarns are held together by the interaction of the looped or interlaced yarns. There is no torque when twistless yarns are used for circular knits.

The system of twistless yarn production, best utilized with cotton and flax fibers, was developed by the Dutch Textile Research Institute (TNO) in Delft. Twistless yarns have less shrinkage than conventional yarns, make a smoother fabric, are more lustrous and brilliant, and give better cover; also,

although the yarns are softer and more absorptive, abrasion resistance is better than in fabrics of the same type with conventional yarns. Production speeds are very fast: 125 to 200 meters per minute, compared with an average of 12 meters per minute for ring spun and 30 meters per minute for break spun.

Another type that gives promise of expanding cotton use in knits is "Prograde" yarn processed with liquid ammonia, produced originally for the manufacture of thread in England. The Prograde process imparts increased strength or permits use of a lower grade of cotton to attain the same strength. It is an alternative process to mercerizing, and costs about half the mercerizing treatment because of elimination of ancillary processes. Advantages of ammonia treated cotton yarns are improved tenacity, increased luster, improved handle, low imperfection rate, and very low shrinkage. When knit fabric of this type of yarn is wet and tumble dried after knitting, tensions put into it by knitting are removed and it is completely stable to repeated laundering. This kind of performance will be a tremendous boost to cotton in knitgoods.

Limited quantities of ammonia treated cotton yarns are marketed in England in a count range of two-ply 20's to 40's. While much of the development work was carried out on two-plied yarns, single yarns have also been tested for knits and have proved to have superior qualities.

Prototype equipment for the manufacture of this type of yarn is to be tested in 1973, prior to commercial scale manufacturing. The sole right to manufacture and market machinery for continuous treatment of cotton yarn by the Prograde process was granted to an English machinery manufacturer by the patent holder. The machinery manufacturer will license processors who will be subject to a royalty payment to the patent holder on a commercial yarn production basis. The IIC has been co-opted to provide technical assessment of knitting yarns and to contribute marketing and promotion expertise on fabrics and garments.

Some consideration is being given to combining break spun and ammonia treated cotton yarns to obtain complementary features of both; the break spun being bulky, nonlustrous and relatively weak, and the ammonia treated cotton yarns being lustrous and strong.

Nylon, polyester, acrylic, blends.—Nylon yarn scored its first big success in knit application in stockings. In addition, it is now used in great quantities for pantyhose, socks, tricot knit fabrics, and double knit and interlock fabrics for cut and sewn apparel.

In the early years, rayon and acetate filament yarn had been used very successfully for knit lingerie and dress fabrics, nylon also became relatively important around the mid-1950's for the same end-uses.

Polyester, which was first available in the mid-1950's, developed in importance before 1960, and found a place in knitgoods when textured polyester was produced in volume around 1963. Until then, flat filament yarns of polyester were used mainly for tricot knitting. Textured yarns extended their use into circular double knit jerseys, which was enhanced by the availability of dyed yarns to capitalize on the patterning capability of double knit equipment.

Acrylic, especially in the bulked form, is used for outerwear such as sweaters. Acrylic outerwear finds a ready market because of its price and ease of care compared to wool. Moreover, it is suitable for apparel during all seasons of the year.

Manmade fiber yarns of two or more fibers either in filament or spun form are sometimes used for knits. For example, in Belgium, yarns of 18 percent nylon and 82 percent polyvinyl chloride are used for underwear because it creates static electricity when worn and is regarded as helpful to people with rheumatism. Blended yarns of high wet modulus rayon and cotton were used for underwear in the United Kingdom, at a price of around 10 percent less at the retail level than for an all-cotton product given 1971 fiber price relationships. Polyester and cotton blend yarns are beginning to appear in women's knit outerwear. Polyester and acrylic blends are also important. Nylon is used in blends with other manmade or natural fibers for reinforcing, adding strength and abrasion resistance.

Textured.—Textured manmade fiber filament yarns have added a whole new dimension to yarn types in the past two decades. Some hold the view that one textured yarn—polyester—more than any other factor has been responsible for the knit revolution.

In 1952, textured nylon became available in West Germany and textured polyester in the United Kingdom around 1963. In the United Kingdom the major manmade fiber producer, Imperial Chemical Industries (ICI), acquired the patent rights for texturing polyester filament from the inventor in 1959. By 1968, it had licensed barely half a dozen throwsters in the United Kingdom, who became known as the Crimplene Club and who sold only under the Crimplene label. ICI maintained strict quality controls over their production. Mergers that occurred in 1971 resulted in ICI owning over 35 percent of total textured yarn capacity in the United Kingdom.

Other manmade fiber producers and throwsters in England and elsewhere make textured yarn on the basis of other processes. Fiber producers in the United Kingdom, the Netherlands, West Germany, and France have developed a close relationship with, perhaps even control of, yarn texturing equipment builders. A number of smaller texturers are closely integrated with knitting operations; most of these are in England. Textured yarn is presently made largely by independent or semi-independent companies, although this may change in due course.

Although both nylon and polyester textured yarns continue to be extremely important, acetate, triacetate, and polypropylene filament are also textured for use in knitgoods. In addition, textured manmade fiber filament yarns, mostly polyester, are being used for woven goods in Western Europe and other major textile producing countries.

The standard polyester filament yarn for texturing in Western Europe has been 150 denier, but this is now being dropped to 135 denier in order to keep price down and to achieve lighter weight fabrics. Filament of 75 denier is used for very light fabrics.

A major target for future development is production of plain fabrics such as classic double pique and interlock. For this, use of two-ply 75-denier yarn results in a better fabric although at higher cost. Manmade fiber producers have been attempting to develop textured yarns that have the appearance and characteristics of spun yarn, but have not been successful to date.

Texturing is accomplished by several techniques, but basically consists of subjecting continuous filament yarns to relatively high temperatures and/or compressive forces to achieve the desired yarn bulk and texture.

Except for certain trade name textured yarns made mainly for hosiery, textured yarn has been processed from so-called feeder yarns by throwsters. However, in 1971, a relatively new aspect of texturing, known as draw texturing, was introduced. This involved the combination of drawing and texturing by the manmade fiber producer in the filament yarn making process. It is claimed that draw texturing results in a textured yarn of vastly improved quality. While this development is yet new, a number of manmade fiber manufacturers are now working on draw texturing techniques. If successful, manmade fiber producers could replace throwsters as the major source of textured yarns.

There is division of opinion and practice in the United Kingdom and on the Continent with respect to the future of "producer texturing." One school of thought holds that the independent throwster will survive. The other school maintains that eventually—perhaps within the next decade—most textured yarn will be made by fiber producers using bicomponent fiber or other fundamentally different methods.

Texturing has improved certain characteristics of flat yarn, but it is not without its drawbacks. The principal one is the tendency to snagging which is aggravated by the openness of many knit fabric products. Also, textured polyester filament cannot be made exactly uniform. Small variations in drawing and twisting and minor deviations in the heat applied to the filament feeder yarn will produce a stripy fabric. Yarn count may vary by as much as 15 denier from lot to lot, and this also can cause problems in fabric manufacture.

Among its many plus factors, textured yarn has low shrinkage, produces fabrics that are free from torque so that they do not snarl or twist, and makes fabrics with excellent wash and wear characteristics without the use of resins.

Textured polyester yarn has a relatively low defect rate, but double knit fabrics are particularly vulnerable because defects are hard to detect while machinery is in operation. Textured polyester is expected to move more rapidly in the future into warp knitting and light weight fabrics. One serious problem in using textured yarn on warp knitting equipment is the difficulty of winding on the warp beams with the same tension, especially if the yarns are fine, so that the yarn will feed into the machine properly.

The future of textured yarns in knitting will depend on a number of factors: Consumer attitudes toward continuation of the pantyhose boom, an end-use that consumes large quantities of stretch yarns; acceptance of still more double knit fabrics for women's wear, the bloom of which has worn off in Europe; the acceptability of knits in men's trousers and tailored clothing, where to date little real progress has been made in Europe; the possibility of success in warp knits; the impact of producer-textured yarns; and solution of certain technical problems.

Other manmade yarns.—Manmade fibers can be engineered for certain characteristics and for specific end-uses. Recent examples of such innovation come from the United States, where the largest manmade fiber producing company has announced production of "fasciated yarn"—a new structure consisting of discontinuous parallelized fibers bound together by a random wrapping of surface fibers, with characteristics intermediate between filament and spun yarns. There will probably be no end to this kind

of experimentation in the United States, Japan, and Western Europe as long as there is a market to challenge the ingenuity of inventors and producers.

Knitting machinery developments

There is little doubt that recent machinery developments have been largely responsible for the dynamic growth in many segments of the knitting industry. Also, there has been an interaction between man-made fiber yarn development and machinery development; the availability of filament yarns with fineness and tenacity has permitted the use of finer and finer gauge knitting machines producing knit apparel of lighter and lighter weight.

The two basic classes of knitting machinery—weft and warp—are divided into many subclasses and variations. Radical developments in circular doubleknit machinery have been responsible for the breakthrough of knits into market areas that were traditionally the reserve of woven goods. Although the greatest changes in knitting technology in recent years have been on double knit machinery, there now may be more effort to improve and increase the product range for warp knits. One of the more promising new developments is machinery in which filling yarns are inserted across a warp knitting bed. The resulting fabrics are stable in width, stretchy in length, and suitable for a wide variety of men's and women's outerwear, household, and industrial goods.

In addition to advances in basic knitting machinery, there have been numerous improvements in knitting needles and in equipment that prepares yarn, supports yarn supply, relaxes knitting structures, and handles knitted fabric with little or no tension during dyeing, finishing, and cutting.

Although the Jacquard approach is still by far the most important method of imparting design, strides have been made in printing knitted fabrics. An innovation called "transfer printing" uses a series of heated rollers or flat press type equipment by which designs on paper are transferred under pressure to fabric to be printed. Best results are obtained with 100-percent polyester fabrics, although nylon and triacetate fabrics can also be used. Satisfactory transfer prints were obtained originally with fabrics containing no more than 25 percent cotton, wool, or silk in an intimate blend with thermoplastic man-made fibers; however, the use of transfer printing on 100 percent natural fibers is to be introduced commercially in 1973. Knitted fabrics have been printed by this technique after having been sewn into garments; by this means, the design can be carried from the front or back of a garment onto the sleeves without a break.

Despite all of the recent advances that have been made, further advances can be expected. New knitting machines will incorporate more flexibility and many types will be able to better handle spun yarns, an obvious plus for cotton.

Cost comparisons

Comparisons between manufacturing costs for similar fabrics made by weaving and knitting processes are difficult at best. It is difficult even to compare cost data for exactly the same fabric manufactured by different companies or different plants of the same company because of the variations in cost factors, different accounting methods, and cost allocations. Irrespective of cost relationships it is certain that all types of weaving and variations of knitting are economically viable for some specific end-uses. Moreover, cost comparisons are impossible for some end-products that can be only woven or knitted, for example, hosiery. Also, the relative cost of converting yarn into cloth may be significant in certain stages in the manufacturing and distribution chain but relatively insignificant in the total cost of a finished product. Realizing these limitations it is of interest, however, to compare the relative costs of producing fabric manufactured by weaving and manufactured by knitting, since for some end-uses they are competitive products.

In general, more capital is involved in setting up a unit of weaving than knitting. Based on a plant producing 2 million meters of fabric (2.19 million yards), the investment difference has been estimated to be about 67 percent greater for weaving, mainly because more machinery and space are needed. True, depending on type and size, single circular knit machines may cost $5,000 to $20,000, double knit machines $20,000 to $50,000, warp knit machines $12,000 to $20,000 or more compared to $2,000 to $8,000 or more for looms, depending on the type, width, and sophistication of equipment attached thereto. Even though modern double knit equipment may cost considerably more than a loom, about one-third fewer machines will yield the same amount of fabric, so that the investment costs for the machine itself may be nearly equal.

The amortization of knitting equipment may be 5 years compared to 10 years for looms, which gener-

ally have longer working life. For weft knitting in particular, there is little or no requirement for yarn preparation machinery, while for weaving, there are several preparatory steps, such as the winding of filling yarn on pirns and preparation of warps on beams, these steps require additional capital expenditures, equipment, and floorspace in a plant. Then, too, finishing equipment for woven fabrics may be up to three times more costly than for knitgoods. Knitgoods can often be finished by only scouring.

Comparisons of manufacturing costs for knitted and woven fabrics have been made by Dr. Gerhard Brockel, associated with a leading Swiss manufacturer of both weaving and knitting equipment. For purposes of comparison, estimates were based on a three-shift operation producing 2.5 million meters of cloth per year, utilizing (1) modern high-speed weaving machinery of 85" width and (2) 48-feed circular double knit machines, both manufacturing light weight women's outerwear fabrics of a wool and manmade fiber blend yarn. In this model, production costs for knitting were slightly higher. It was pointed out, however, that for different end products and different labor conditions, cost relationships would shift.

The results of this study may be summarized as follows: A major difference was the higher cost yarn needed for knitting, estimated to be about 8 percent over the cost of weaving yarn. The shorter depreciation period for knitting machinery and greater amount of defective materials produced by knitting equipment were also major cost items. (Estimates suggest defect rate of 8 to 15 percent for double knits compared with 2 percent rate for wovens, although defective woven goods are correctable to a greater degree.) Finishing costs were estimated to be approximately 7 percent lower for knit goods. On the side of labor productivity, some cost differences are notable. To manufacture the same quantity of goods, 10 operatives for three shifts, or 30 man-days, would be required for knitting; 8 operatives for three shifts plus 4 laborers working one shift on preliminary operations, making a totl of 28 man-days, plus some additional labor in the mending department would be required for weaving. Lower costs for garment make-up are involved for woven fabric garments than for knit fabric garments that are cut and sewn.

A similar exercise was undertaken by Dr. W. P. Schneider, associated with the same machinery manufacturer. Schneider's study was based on shirting fabric utilizing 40 denier nylon for the knit fabric and blended 50 percent cotton/50 percent polyester yarn for the woven fabric. Fabric weights were considered comparable. Despite the differences and variations involved, it would appear that there is no great advantage that would give either weaving or knitting a leading position from a cost standpoint. This conclusion seems warranted, particularly at this time, when the full potential of neither woven processes, weft knitting processes, nor warp knitting processes has yet been fully exhausted.

Problems of knits

The wondrous world of knits is not without problems to the knitter, the converter, the apparel manufacturer, and the consumer. The major attribute of knitted goods, stretch, is in many ways a disadvantage in comparison with the firmness and predictability of woven fabrics. Other difficulties arise from the type of fiber from which a knit product is made. These difficulties appear from the manufacturing stage to the point of final use. A technical explanation of the problems encountered in the manufacturing processes is outside the scope of this report; however, the types of problems that are particularly important are mentioned.

Newer high speed knitting equipment has less tolerance than looms. The range of yarn sizes that can be used on some is limited, and it is difficult to keep the equipment running efficiently. Some have a high rate of "down time." This is particularly true of Raschel and of certain other specialized types of equipment. Consequently, the much-heralded high speeds of knit production must be evaluated against the actual productivity of each type of equipment.

Yarn problems.—High speed knitting equipment, particularly for warp knitting, places great demands on yarn. Lack of hairiness, pliability, elasticity, and strength are very important characteristics for knitting yarns. It is important also that yarn count (size) be even or, at least, that the deviation from count be uniform.

It would appear that requirements can best be met by untextured filament yarn, which is inherently stronger, smooth, and quite even in diameter compared to spun yarn. Friction is created as yarn moves through knitting machinery, especially warp knitting equipment; this friction tends to damage spun yarn. Because spun yarn is relatively uneven, it requires slower speeds on some machines to avoid excessive breakage.

In warp knitting, there are about 25 such points of friction. In West Germany, tests run on warp knit

machinery produced 1,200 courses per minute using flat filament yarn, about 800 courses per minute using textured yarn, and under 800 courses per minute using cotton yarn. Tests have demonstrated, however, that given the right combination of yarn and machine, spun yarns need not be knitted more slowly. Cotton interests are continuing to seek ways to prepare cotton yarn that will utilize fully the high speed potential of knitting equipment.

From a technical standpoint, cotton has no greater problems than any other spun yarn, which is not only somewhat uneven but hairy. Cotton or wool must, of course, be spun to be made into yarn, As a general rule of thumb, it is estimated that the cost of operating knitting equipment may be up to 30 percent greater for spun yarns than for filament yarns. It is estimated that 75 to 80 percent operating efficiency can be achieved with spun yarn, compared with 93 to 95 percent for synthetic filament yarn, although it is recognized that efficiency rates vary by type of equipment, yarn type, yarn characteristics, and the complexity of the design being produced.

Another drawback of spun yarn is the creation of fly as spun yarn moves through processing. Fly is short, light-weight waste fibers that break loose during manufacturing and which may float in the air for a while before settling. When fly gathers at friction points in the machinery, it can cause difficulties, including needle deflection or breakage, which in turn results in holes in the fabric. If fly is not properly handled, especially on fine-gauge equipment, yarn breakage will also result. Modern knitting equipment has automatic devices for collecting fly so that the problem is no longer as significant as it once was. Proper lubrication of cotton yarn reduces fly problems and also helps deal with problems related to tension and friction.

For yarns used on circular single and double knit machines, and on Raschel warp knit machines, fineness is not a critical factor. Coarser, less expensive yarns may be used. Yarn fineness is extremely important, however, for use on fine-gauge tricot equipment. Manmade fiber filament yarns for warp knits are in the 15-20 denier range. Fine-count cotton yarns can be knit on tricot equipment providing they are sufficiently strong. Cotton yarn costs rise sharply with increased fineness, and must be compared with alternatives; however, higher yarn costs should not deter the knitter who is willing to produce a product for which commensurate prices can be charged.

Barré and other knitting defects.—A major difficulty in knitting when using certain types of yarn, notably textured polyester, is production of goods with "barré," defects characterized by repeating bars or stripes. These may be caused by differences in the length of yarn in a given length of fabric because of differences in the yarn feed from the cones to the needles or differences in the tightness of the stitch itself. Barré may also be the result of differences in yarn texture, especially of manmade fiber filament yarn, which has been textured, resulting in variations in the manner in which it will knit. Differences in yarn texture can be caused by variation in the degree of crimp in individual filaments, differences in overall bulk of yarn, or the overstretching of yarn. Some of the new double knit machines are fed from as many as 48 cones of yarn, each of which must contain yarn that is absolutely uniform and fed under the same tension in order to produce a defect-free fabric. While it is claimed that textured polyester filament yarn has a defect rate of about only 2 percent, even that amount can ruin a great deal of fabric if not detected and eliminated. This raises the question of the necessity or desirability of the knitter to inspect yarn from different packages for uniformity before use, although within-package variation would remain a source of trouble.

If manmade fiber yarn or even blended polyester/cotton yarn is run through knitting equipment too fast, melt spots are produced, and the resulting holes and slubs create defective fabrics. Moreover, improper design of knit fabrics result in flimsy or unstable fabrics subject to distortion or damage in handling.

In order to reduce distortion, yarn should be introduced to the knitting needles with "positive feed" devices that allow knitting to take place at lower yarn tensions; on the other end of the operation, goods must be taken up on rolls without stretch. Even with all the precautions that can be taken, it is not unusual for some types of knitgoods to vary in width from plus to minus 5 percent.

Dimensional stability.—Fabrics for outerwear are required to be stable dimensionally and easy to care for. As they come from a knitting machine, cotton fabrics have considerable elasticity but they do not recover well when stretched. It is desirable to eliminate such dimensional instability to as great a degree as possible, and it can be done to a certain extent by such techniques as construction changes, resin treatment for 100-percent cotton products, and feeder blends where a yarn of textured polyester is fed into the knit structure interspaced with cotton yarn. On the other hand, knitgoods of thermoplastic fibers such as nylon and polyester and even polyester blends with cotton or cellulosic fibers or ratios no less than 25 percent polyester can be heat-set to shape. The IIC is seeking through research to find finishing

techniques for cotton knits that achieve shape retention when worn or washed.

Shrinkage.—The tendency of knits to shrink is a problem every step of the way from the knitter to the consumer. The interlooping of yarns builds tensions into knit fabrics. This tension can be largely removed. Fabrics treated for shrink resistance will have a residual shrinkage of 2 percent or less, compared with 3 to 16 percent for untreated fabrics, depending on the fiber and knit stretch.

Shrinkage is also a serious problem in the processes of scouring (washing), bleaching, dyeing, printing, and finishing of knit goods. Unless preshrunk by the knitter, fabric widths change in the dyeing and finishing process and reach the final finishing frame at variance with the desired uniform width. In order to meet cutters' demands for specific widths, finishers have been known to stretch fabrics as much as 25 percent, which will result in shrinkage equivalent to two dress sizes during subsequent steaming by an apparel manufacturer.

Shrinkage is a problem with knits of any fiber, but to a greater extent with cotton than others. Cotton knits are readily distorted during the knitting and finishing processes. When knit goods are wetted, the stress relaxes and the knit structure tends to assume an untensioned condition, which results in shrinkage after washing and tumble drying.

The degree of shrinkage depends upon the construction characteristics and shrinkage potential of the fabric; each type of fabric or knit product has different shrinkage factors. Moreover, for some types of fabrics, shrinkage is progressive, i.e., continues for a number of washings. Tests of branded underwear on the Dutch market were found to shrink from 12 percent to 18 percent, amounts that often result in garments that were too small after the first washing. A shrinkage factor of about 5 percent is considered commercially acceptable, and consumers have accommodated themselves to this degree of shrinkage by buying one size larger than body measurements would seem to require. One large French knitter reported the inability to find a method of reducing the shrinkage of fully fashioned cotton goods to 8 percent or less.

Sometimes the fault lies with the apparel manufacturer who tries to reduce costs and utilizes his machinery poorly. For example, properly fitting undershirts in a full range of sizes can only be made by a set of circular single knit machines with diameters graduated by 2-inch increments from 12 to 24 inches. Some mills have machinery of only one or possibly three sizes. The product thereof is stretched to make a full range of sizes which shrink back to the original one to three sizes after laundering. The problem of lengthwise shrinkage is aggravated by the use of tumble dryers, but these are not generally available for home laundry in Western Europe.

Various systems for reducing shrinkage are available. One of the best known and widely used systems mechanically compresses knitted stitches in the lengthwise direction to compensate for the inherent shrinkage built in by tension introduced during the manufacturing and finishing processes. With "relaxing" systems using steam, vibrations, or other mechanical means, shrinkage can be limited to 5 percent, sometimes even as little as 1 percent. However, poor treatments will give uneven shrinkage and are not satisfactory.

Ironically, one European underwear manufacturer who had perfected his preshrink system found that he could not educate consumers to buy the correct size because, despite the information on the package, they did not change their life-long habit of buying a size that was too large before laundering. With his underwear, it was also too large after laundering. As a result, he abandoned the manufacture or preshrunk underwear.

Even under optimum conditions, there are changes in fabric construction when compactors are used. The yield in fabric length is decreased proportionately to the shrinkage; consequently, if the same yarns and construction are used, fabric weight is increased by the shrinkage treatment. In order to arrive at approximately the same product after shrinkage, the number of stitches per inch can be decreased, yarn sizes can be decreased, and finished widths can be increased. Apparel manufacturers would also need to make adjustments in pattern sizes and cutting tolerances.

Economical shrinkage control techniques are basic to expansion of cotton's role in knitted outerwear. There are several reasons why the preshrink treatments that are available have not been more widely used. The principal objection is the loss of length and therefore of value, since in Western Europe knit fabrics are usually sold on the basis of length. Then, too, manufacturers have not been pressured by consumers for shrinkproof garments, but with the growing importance of mail order companies and chain stores in Western Europe, standards are being tightened and more knitted cottons, especially for outerwear, are being given shrinkproof finishes.

Bleaching, dyeing, printing.—As for woven goods, there are two basic methods of obtaining color in knitted products: (1) Use of colored yarns, and (2) printing or dyeing after fabric or garment is manufactured. In Europe, a knitter can obtain yarns

in a wide range of colors from spinners. If a knitter is not making yarn-dyed goods and does not have facilities to dye fabrics, this is done on a custom basis.

In bleaching and dyeing, continuous processes are not suitable for many knit fabrics, especially of manmade fibers and of blends with cotton. The continuous process makes a rope of the fabric which is pulled through guides into and out of dye baths, bleach tanks, and dryers. The method of handling results in shading and streaking of the color, and sets creases in fabric—a very serious problem for manmade fibers, unlike cotton. As a result, it is more suitable (and more expensive) to use slower batch processes which involve more openness and less tension on the fabric being finished.

It is difficult to dye or print polyester and nylon goods because dye uptake is not uniform. In addition, if pastel colors are used, it is difficult to remove the dirt that accumulated in the manufacturing process without spoiling the appearance of the fabric.

From a fashion point of view, it may be significant for some end-uses that cotton does not take as brilliant a dye as some types of manmade fibers. Variability in cotton yarn necessitates more frequent adjustments in the dye formula and, for some deep colors, a longer time to achieve the same effect. However, it is even more costly to dye polyester/cotton blends because two types of dyes are required to do the job. This problem is sometimes met by stock dyeing the two fibers separately before spinning into a blended yarn.

Apparel maker's problems.—The apparel manufacturer has his own set of problems with knits. One of the most important relates to the dimensional instability of knit fabrics, which require careful tensionless spreading onto the cutting table and special care during garment construction. The less rigid character of knit fabrics cause difficulties in the transfer of cut garment pieces in automated plants, compared to the more rigid character of woven fabrics that are easily handled by pneumatic devices. These problems can be mitigated by the use of proper equipment and specially trained personnel. The high defect rate for knit fabrics gives cutters using them more difficulty than they have with woven fabrics. This has led to discussion of the need for industry-wide standards for knit goods.

The difficulties of sewing fabrics with a "fat hand" have required cutters to utilize patterns for apparel with minimal construction details, thus giving rise to design monotony for knit garments. Other special problems are encountered in making up knit apparel of thermoplastic fibers, such as the need for using sewing thread with elastic properties and linings and other construction accessories with sufficient stretch so as to be compatible with outerwear fabrics, for adjusting patterns to account for behavior differences between knit and woven fabrics, for using finishing techniques that account for the special problems of knit garments. Needle holes in garments can be avoided from needle friction only if slower than normal needle speeds are used when stitching thermoplastic knit fabrics. The use of special ball point needles also helps to avoid needle cutting.

Removal of stitched seams, hems, etc., in knit apparel by apparel manufacturers, retailers, or end-users does not yield satisfactory results, Ultrasonic "stitching" is one method used to avoid some of these problems. Major alterations cannot be satisfactorily performed on garments that have been set-to-shape. For example, retailers experience problems cuffing knit thermoplastic fabric trousers since they do not have equipment to reset the shape of the bottom of the trouser leg. This limits the acceptability of knit apparel for certain styles of garments.

Consumers' problems.—From the consumer's standpoint, knits are not without drawbacks. Basic cotton single knit underwear tends to lose its shape and is subject to progressive shrinkage. Shape retention has been one of the strong points of double knits for outerwear. Unfortunately, despite advances, cotton double knits leave much to be desired; when stretched, they sag and do not recover their shape completely. It will be a great boon to consumers when cotton's progress in the laboratory with respect to shape retention reaches the marketplace in all end-uses.

Polyester filament double knits have excellent shape retention, but another more serious problem—snagging. The texturing which gives polyester filament enough cover for use in outerwear sets loops in the filaments which easily catch on everything that is not perfectly smooth. If the fabric has not been treated with antisnag finishes, double knit garments soon have fuzz or pulled yarns at points of contact with rough objects and places of friction. In obtaining the convenience of easy care, the consumer pays a high price in appearance. Warp knits give better performance on this score. Another problem with filament yarn double knits is their air porosity—they are breezy and uncomfortable in the wind or cold. This can be overcome to some extent by the use of linings or by the mixture of spun yarns. As a result of fiber properties and their construction, certain nylon and polyester knitgoods are transparent, especially in light colors. Then, too, some women object to the sameness of polyester double knit fabrics, which may account in part for the lack of

recent growth in Europe for the use of this fabric in women's outerwear.

Polyester and nylon knits are subject to burn holes from hot cigarette ashes, fire sparks, and so forth. Another serious consumer problem is oily spot and soil retention, especially by polyester fabrics; consequently, the washability of such apparel is of questionable value if the apparel does not "come clean" in the wash.

According to the International Institute for Cotton, about one-half of cotton's market is in end-uses where easy care finishes are important. IIC recognizes that failure to find an answer to this problem for both knitted and woven outerwear could have a serious effect on cotton's longterm future as a textile fiber.[7]

At present, there is no treatment for 100-percent cotton products that achieves satisfactory easy care and shrinkage control without loss of other desirable properties; however, the IIC continues to concentrate effort on finding an easy care finish for 100-percent cotton products that will perform well from a wear standpoint. Experiments of other organizations on 50/50 cotton/polyester blends show improvement of wear characteristics, but result in pilling and dyeing problems.

As in the case of shrinkage control for underwear and industrial fabrics, there is for outerwear fabrics relatively new commercial equipment which combines a resin treatment with mechanical compacting.

Easy care characteristics remain a major consumer attraction in Western Europe, even though their advantage cannot be fully captured for the lack of tumble dryers in the home. Consequently, the search for economic methods to meet the problem is being pursued by the International Institute for Cotton and such other organizations as the Southern Regional Research Laboratory of the U.S. Department of Agriculture, and Cotton, Incorporated, a research and promotion organization in the United States.

Commercially acceptable finishing treatment, shrink resistance, dimensional stability, and easy care properties would greatly improve cotton's competitive position.

INTERFIBER RELATIONSHIPS IN END-PRODUCTS

The relative importance of knitgoods in several major product categories varies greatly. Universally, knitgoods have an "exclusive" in hosiery and sweaters; in most countries, woven goods have almost all of the sheet market. Between these two extreme positions are numerous commodities in which knitgoods are important, and in many cases rapidly advancing.

Where information could be found, this section presents a brief review of the relative importance of cotton to total knitgoods markets by major products. The data are not uniform by country; for some, they are completely lacking. Analysis of that available information shows that for many products the position of cotton and wool has weakened as manmade fibers have assumed greater importance.

Stockings, pantyhose, hose

Manmade fibers holds more than 80 percent of the hosiery, pantyhose, and hose market in Western Europe. Relatively small quantities of cotton hose are manufactured for specialty uses, infant's wear, and luxury items. France produces a sizable quantity of wool hose compared with other countries, although notable quantities of wool hosiery are also manufactured in the Scandinavian countries and in Austria.

Fabrics

Knitted fabrics as well as woven fabrics should probably not be considered end products, but rather semifinished products, since they are further processed into apparel and household and industrial products. Some relatively small share of total knit fabrics has been sold over retail counters for dressmaking, and this segment of the market has been rapidly expanding in recent years. For purposes of this analysis, such fabric is considered along with that further processed in factories.

Knit fabrics are of many varieties; they range from light weight filmy materials for lingerie and blouses to heavy materials and fake furs for men's and women's coats, with endless numbers of types between these two extremes. In recent years a wide variety of suitable knit fabrics has been produced for women's and children's dresses and suits. Fabrics for men's suits, jackets, and slacks are of two major types—those that

[7] "Improving Cotton Fiber Structure," by S. Allan Heap, Research Manager, International Institute of Cotton, in paper given at Cotton Improvement Conference, Atlanta, Ga., January 1971.

appear frankly to be knits and those that are imitative of woven fabrics.

Interstoff Fairs, held semiannually in Frankfurt, Germany, for the purpose of bringing together sellers and buyers of fabric in Europe, have recently reflected the great upsurge of interest in and use of knit fabrics for outerwear. Some knit fabrics shown at Interstoff are readily identifiable as knitgoods; others, such as knit corduroy, are not. A full range of fabrics is shown—single knit nylon, acrylic knit fabrics, and wool knit fabrics that are printed, plain, and Jacquard, and polyester double knits of all types, and blends of a variety of fiber combinations. Specialty fabrics of lacy appearance, and nylon jerseys processed to have the "wet look" all seek the attention of European and American fabric buyers.

The International Institute for Cotton maintains a "Cotton Center" at Interstoff which displays many cotton fabric samples of new design ideas. Knits include yarn dyed single cotton jerseys and cotton pique from Italy, yarn dyed cotton double knits from France, heavy Raschel cotton fabrics from the United Kingdom, and many other exciting innovations from all over Europe that have proved attractive to the apparel manufacturers of Europe and the United States.

Fabric innovations are also seen elsewhere. In the Netherlands, knit pile floor covering of cotton has been developed. All-cotton knit terry cloth with improved stretch recovery especially suitable for beach and sportswear is available in the United Kingdom. Double knit fabrics of cotton for outerwear both in 100-percent cotton and cotton in blends with polyester, acrylic, nylon, and wool are found. Coated fabrics for apparel and household and industrial uses are made almost entirely from plain cotton jersey base cloth. However, despite the niche that cotton knit fabrics presently have, it is small compared to the place of manmade fibers, particularly polyester and acrylic, in the knit fabric area.

Data available indicate that while cotton consumption in knits has increased, cotton did not share proportionately in the explosive expansion between 1960 and 1971. For example, in 1960 France produced 16.7 million pounds of knit fabrics; 11 years later the total was 64.9 million pounds. Although cotton knit cloth production in that period increased 35 percent, cotton constituted only 12 percent in the latter year, compared to over one-third in the former. On the other hand, noncellulosic fiber constituted 75 percent in 1971, compared to 27 percent in the earlier years.

For the United Kingdom, the data on knit fabrics can be estimated by combining data for weft knit fabrics as published by the National Hosiery Manufacturers' Association[8] with the data on warp knit fabric provided by others, who are mainly producers of woven fabrics. In the period 1960 to 1971 production of knitted fabric increased over five-fold. The most rapidly growing segment was weft fabrics. There is no fiber breakdown available for warp knit fabrics, but it is estimated that only about 5 percent of total fiber used is cotton. In 1971, 100-percent cotton constituted only 10.3 percent of the yarn used for weft knit fabrics compared to over 62 percent in 1960. Blended yarns with cotton were about 2 percent of total. Manmade fibers, especially noncellulosics, accounted for over 70 percent in 1971 compared with less than 12 percent in 1960. It is apparent that in the United Kingdom, cotton has not shared in the growth of knit fabrics although some improvement in cotton's position was noted in early 1972.

These extremes are not typical of other Western European countries. The proportion of cotton to total fibers used in the production of knit fabrics in the United Kingdom is less than in other Western European countries in view of the substantial control by manmade fiber producers of knit production facilities in that country.

Underwear

Knitted underwear remains a stronghold for cotton throughout Western Europe. Even so, in the years for which data are available, it appears that cotton's share of total knit underwear market is dropping.

Of the units of underwear domestically produced and sold in the domestic market, cotton accounts for over 90 percent in Belgium (not including pantyhose, leotards, and tights), over 70 percent in France, Denmark, and Switzerland; 55 to 60 percent in Norway and the United Kingdom, and about one-third in Austria, Finland, and Sweden. In the Nordic countries, a relatively high proportion of wool is used. Italian production data (which include exports) indicate that underwear of cotton, wool, blends, and fibers other than manmades account for over 60 percent of total units.

Instead of the plain or ribbed single jersey used in the United States, men's undershirts in Europe are made of several basic fabric types. The most important is a circular knit eyelet fabric. Interlock,

[8]In United Kingdom, the term "hosiery" has traditionally included the entire knitting industry. However, some effort is now being made to revise the use of the terms "hosiery" and "knitting" industry in line with practice elsewhere.

which is a type of double knit, and Raschel, mainly net, make up the other main knit fabric constructions used for this purpose. The largest chain store organization in the United Kingdom sold 100 percent cotton men's underwear exclusively until about 1971 when printed nylon was introduced. In other retail outlets in the United Kingdom, nylon warp knits had a large share of the market until about 1965, when they were seriously challenged by garments made of blended yarns.

Women's lingerie is made of various filament yarns—mainly rayon, acetate, and nylon—and also of cotton/manmade fiber blends of various kinds. Slips and half-slips are of nylon in almost all West European countries. Pajamas are made of these fabrics and of cotton terry cloth knits. Cotton accounts for approximately 75-85 percent of fiber consumption in women's undervests and panties in West Germany, the Netherlands, Belgium, and Denmark, and for 50 percent in Austria and France.

Recently, manufacturers have gone into outerwear by imaginative use of underwear production equipment and underwear fabrics. T-shirts, traditionally white, are dyed bright and dark colors or trimmed with applique to be used as outerwear, especially for the youth market. These are mostly cotton. On the other hand, body shirts or body suits, which may be considered a further development of leotards and tights, may be considered either underwear or outerwear. For these, manmade fibers are generally used.

It is possible that in this apparel area, the appeal of easycare has reached its zenith and that consumers will henceforth be more interested in comfort. The use of cotton in blends or in 100-percent cotton products would aid cotton recover part of the underwear market.

Outerwear

It is estimated that apparel made from knit fabrics accounted for 40 percent of total and 60 percent of women's apparel in 1971.

Knit outerwear is an ambiguous term. It may be defined to include only those items finished by knitwear manufacturers, or it may be defined to include garments manufactured from knit fabrics produced by knitters and weavers. If broadly defined, the major categories of knit outerwear are sweaters, men's shirts, women's shirts and blouses, and more recently dresses, suits, and trousers. Less important categories are swimsuits, berets, infants' wear and the like.

The data collected by the International Secretariat of the Knitgoods Industries in Paris indicate fiber distribution for the outerwear produced by knitters in some Western European countries. In those countries for which data are available, 50-70 percent of the units produced are of manmade fibers, with wool running a poor second. Cotton has relatively poor position, accounting for around 15 to 25 percent of total units produced in those countries.

Shirts

Nylon tricot knit business shirts were of high importance in most of the major markets of Europe in the early 1960's. In 1970, they were estimated to be 30 percent of the market in West Germany and the United Kingdom, and about 15 percent in Belgium. By 1972, these shirts were estimated to be only 20 to 25 percent of the West German market. In the Netherlands, they had earlier constituted 40 percent of the market which is remarkable since the Netherlands is generally thought of as a stronghold for cotton, but by 1970, these knits were only 5 percent of the business shirt market. In France, also nylon tricot knits are less important than formerly.

In each of these countries, the business shirt market moved away from nylon tricot knits; as the market became very competitive, profitability was seriously reduced, and consumer resistance to the product was experienced. Knit nylon shirts have been replaced largely by 100-percent cotton permanent press woven and polyester/cotton blends of woven or knit fabrics.

In Italy, knits are estimated to be about 15 to 20 percent of the total business shirt market. About two-thirds of these are cotton or cotton blends with cellulosic manmade fibers.

In France, an internationally famous knit sport shirt, LaCoste, has been traditionally made of cotton. However, a new line of knit blended shirts with this famous label was introduced in 1971.

The development of men's dress shirts as a fashion item has led leading branded shirt manufacturers to turn their attention to fine-cut single jersey Jacquard fabrics. For this end use, there has been a move away from 100 percent textured polyester which had had a long run in sports shirts, toward 100 percent spun fabrics, mainly of acrylic and of blends using textured polyester and spun polyester with cotton or wool.

Women's suits, dresses, blouses

For these end products, the importance of fashion probably outweighs function. Fashion designers have

the problem of finding a wide variety of distinctive fabrics for various types of women's outerwear; knits were seized upon as they added a new dimension to the materials with which to work.

There is a wide range of knit fabrics suitable for women's and children's outerwear, from 3-ounce fabrics suitable for blouses and children's wear to 22- or 24-ounce cloths designed for coats and to medium weight cloth designed for dresses and suits. The variety of textures obtained by knitted designs, dyed or with colored yarns, added to the many types and weights of fabric offer a great diversity of fabrics for those end uses.

As a consequence, knits have assumed an important place in women's outerwear. It is estimated that of total dresses produced in 1969, knits accounted for 40 percent in the Netherlands, 30 percent in Belgium, 48 percent in Germany, 50 percent in Scandinavia, 55 percent in the United Kingdom, and only 20 percent in Spain.

Of these, most were textured polyester, some were wool and acrylic, and very few were cotton. Of total women's suits produced in 1969, knits accounted for 50 percent in the United Kingdom and 55 percent in the Netherlands; of these most were polyester double knit. Of total women's slacks, about 30 percent of the European market was knits, of which about one-third was stretch nylon ski-pants. In West Germany, it is estimated that of total women's outerwear of all types, 60 percent was knitted and 40 percent woven in 1970 and proportions were 50/50 in 1971; in 1972, 45 percent was knitted compared to 55 percent woven.

Textured polyester double knit fabric is one major reason for the relative importance of knits in women's outerwear. It has better consumer characteristics than earlier knitgoods used for these purposes. Originally textured polyester double knits seemed to be an unending source of new fabrics, unbound by price or traditional applications. Consumer response to comfort of the stretch and convenience of the easy care and shape retention gave further impetus to its use. The early success of textured polyester double knits was bolstered by activities of fiber producers, yarn suppliers, garment industry leaders, as well as machinery makers who met the rapidly expanding demand for more flexible and improved machinery.

Fashion is fickle and ever dynamic. The use of textured polyester double knit passed its zenith in Western Europe in 1970. While there is still a large proportion of knit outerwear for women, not as much of it is made of textured polyester double knit as formerly.

Textured polyester is also used for warp knits for women's dresses; it has better drape and softer touch than circular knits, but less shape retention. Nylon jersey is also a popular dress fabric because of its soft drape and the brilliant colors that can be obtained. Pattern range for prints is also extended by the availability of transfer printing techniques for thermoplastic fabrics. While the use of textured polyester double knits may have passed an all-time high in women's outerwear, the position of knits remain strong in this market.

Men's slacks, jackets, suits

As of 1970, knits held a minor place in this category of apparel; but a major push was being made to make up for the reduced demand for women's knit outerwear. Men's slacks, jackets, and suits are generally made of wool woven fabrics, heavier in Europe than in the United States. The gain of knitgoods in these products does not constitute a threat to cotton markets, except as inroads are made into the market for jeans. Most men's outerwear knitgoods have been made of textured polyester or polyester/wool blend double knit fabric. While in Europe the discomfort of polyester in hot weather may be minimal except in the Mediterranean countries, polyester outerwear for men feels too cold to wear in the winter, unless combined with wool.

As of 1970, polyester double knits had captured only 1 percent of the men's suit market and 5 percent of the trouser and jacket market. Goals of manmade fiber producers within the next 3 to 5 years are to gain 10 to 15 percent of the suit market, 20 percent of the market for men's jackets, and 30 to 40 percent of the important trouser market.

The problems of snagging and air porosity with 100 percent polyester double knits have caused makers to turn to blended polyester/wool, acrylic, cotton, or rayon and so-called combination yarns in which as much as 30 percent spun yarns are employed. Polyester/wool double knits seem to be particularly suitable for men's outerwear. Other types of knitgoods, such as Raschel, warp knits, and weft insertion fabrics are being tried, although cost relationships may not be favorable.

In order to further their aims, an "exclusive club" of knitters under the sponsorship of a leading European polyester producer has pooled its knowledge and experience in both double knit and single knit fabrics in order to provide men's apparel makers with larger fabric collections. In the United Kingdom, the bastion of conventional tailored

clothing for men, an "easy suit" has also been introduced by another leading fiber producer. Texture, design and color, instead of a pseudo-woven look, are emphasized in Western Europe for men's knit outerwear. Early in 1972, a machinery manufacturer in the United Kingdom introduced a 28-cut single jersey machine considered by them to be "ideally suited to the production of single jersey Jacquards for the men's outerwear market currently developing."

By mid-1972, it was apparent that knitgoods for men's outerwear was not particularly successful in West Germany; and in France, knit fabrics that were shown for this end use all had the appearance of woven fabrics. On the other hand, manmade fiber producers in the United Kingdom were continuing to push polyester blends of double jersey for men's outerwear.

Household items

It is estimated that household items not including floor coverings constitute slightly less than 20 percent of the West European fiber market. Household goods account for roughly one-third of total raw cotton consumption. Not unexpectedly, then, manmade fiber companies are doing a great deal of research directed toward breaking into household end uses with knits and other types of textile products.

At one point, brushed warp knit nylon sheets held 15 percent of the sheet market in the United Kingdom. They were utilized in hotels, motels, and homes because they were light-weight, durable, easy to care for, and comfortable; however, the popularity of these warp knit sheets has lessened, and polyester/cotton woven sheets have gained greater acceptance. Knitted sheets have gained only 1 or 2 percent of the sheet market on the Continent.

Double knit fabrics for upholstery have been used in Europe for about 6 years; generally they have been made of stretch nylon yarn. Single knits have been popular as slip cover fabrics. The ability of knit fabrics to stretch over irregularly shaped furniture eliminates some problems associated with the fit of upholstery fabrics. Both close-sheared and shaggy types of deep pile knits offer additional style dimensions for the furniture manufacturer.

Industrial items

Industrial uses constitute 25 to 30 percent of the total fiber market in Western European countries, but knitted fabrics hold a limited place in industrial end-uses.

Cotton single jerseys are very important as a base coating fabric for use for automobile upholstery, ceilings, and walls as well as for furniture and shoes. Until about 10 years ago, coaters used woven base fabrics, which yielded about 10 percent stretch. Using cotton knits 60 to 120 percent stretch can be obtained. Single cotton jerseys are also used for packaging foods, such as ham. Cost relationships prohibit their use as backing for wallpaper. Recent experiments with knitted body parts for medical applications have utilized noncellulosic fibers exclusively.

Jersey fabrics are coated with polyvinylchloride, polyeurathane, and rubber and, for each, cotton forms the best base. Even though the tensile strength is somewhat less than for woven coated fabrics, the load distribution is better, so despite change-over costs, the coating industry adopted knit base fabrics.

West Germany has successfully tested knitted fabric of specialized nylon as a grass substitute for sports fields, but this development is presently on a trial basis.

OUTLOOK

Will the dynamic growth of knits in Western Europe continue? Must it be assumed that the sweeping success of manmade fibers in this growth will further erode cotton markets? Or has the knit tide already reached high-water mark? Will cotton be able to strengthen its competitive position in knits through continued research and market promotion efforts?

The answers to these and other related questions are of utmost importance to fiber producers, both natural and manmade, to machinery manufacturers, textile mills, and apparel plants. Estimating future market shares must take into account the economic advantages, quality and prices for comparable products, and, some think most important, fashion and consumer habits.

There is a well-placed body of opinion that holds that the knitwear expansion will continue in Western Europe and that it will grow into many fields, such as men's wear, where it is now relatively unimportant, such expansion being fostered by the apparel industry as well as the knitting industry.

Forecasts of some manmade fiber companies reflect this point of view. The new Textile Council of the United Kingdom has also suggested that the present trends will continue, and that there will be further loss by spun yarn woven fabrics and major gains by knit fabrics. Their forecast for the United Kingdom indicates that by 1975 only 57 percent of fabrics produced will be woven, compared with 70 percent in 1968, and 85 percent in 1955.

In its publication "Hosiery and Knitwear in the 1970's," the National Economic Development Office (United Kingdom) forecasts that knitted garments which in 1962 were 61 percent wool, 27 percent manmade fibers and 12 percent cotton would by 1978 be 20 percent wool, 77 percent manmade fibers, and only 3 percent cotton.

If this relationship is valid for the United Kingdom, such relationships might also be valid for other Western European countries with similar climates. Then too, since Britain has become a member of the Economic Community, the influence of British manmade fiber producer on fiber consumption patterns in Western Europe may be a factor in expanding the use of manmade fibers in knit and woven textile products.

According to the International Committee for Rayon and Synthetic Fibers (CIRFS) in *Forecast, 1980,* "Progress in knitting in Europe is continuous and the range of uses ever widening. Large expansion will continue mainly because of the opportunities afforded by the synthetic fibers which should enable knitted fabrics to enter nearly all textile fields."

On the other hand, the rapid trend to knits may already have been slowed, and the boom may have already reached a peak. It is probable that any growth from this point forward will be more difficult and consequently more gradual than in the immediate past. It appeared that a general shakedown was taking place in knitwear apparel beginning in early 1972. Double knit fabrics in particular were coming under increasing competition from other fabrics, especially for women's wear. A trend away from knits was noted in France in 1972.

In its annual report for 1971-72 a major British manmade fiber producer, also very important in knitting, observed that the rapid rate of increase in world demand for jersey fabrics in recent years was not sustained in the year under review and that there was a massive price decline.[9] According to a Swiss knit machinery producer, double knit fabrics for women's wear in Europe is on the wane. In the United Kingdom, a major knit machinery producer thought that the general slowdown in double knits would get worse. It appears that the boom has at least cooled. A hard search for markets may have already begun.

As incomes and purchasing power increase, consumers will be more concerned with fashion and ease of care rather than with wearing qualities and cost for large segments of the apparel market. Knits are now no longer new, and will no longer sell just because they are knits. While there is still much to be said for the comfort stretch of knit garments and the resultant ease with which they are worn, new garment styles may demand more individuality. Moreover, stretch is no longer the exclusive prerogative of knits, as some success is being achieved with woven stretch apparel. The relative sameness of polyester double knit fabric, especially for women's clothing, may be a deterrent to its further expansion, despite efforts of knitters to vary designs, fabric type, and colors. Some relief from the monotony may be attained through the use of spun yarns in combination with or instead of textured filament. According to one West German textile machinery manufacturer, some trend away from manmade fibers can be expected, as consumers again turn to natural fibers.

Despite the problems with which cotton is confronted in the knit arena, the future holds promises of better things to come in apparel.

Cotton knits may hold their strong position in the underwear market, although manmade fiber interests have attempted to penetrate the underwear market with 100-percent nylon jersey briefs for men and blends of cotton and polyester. These have not proved popular items in Western Europe.

There is more interest in cotton hose for men and boys than the supply on retailers' shelves would indicate. Cotton hose is better for one's feet according to medical advisors because it absorbs moisture and does not exert pressure on the foot as do stretch hose. Hosiery manufacturers are not meeting consumer demand for cotton hose except in sports socks and high-end luxury items. They could probably do so with profit if a suitable method could be found to assure support on the leg. Since cotton hose wear out sooner than nylon, more frequent repeat orders could be expected.

The preferred laundry method on much of the Western European continent is "boiling." Whether this is necessary is questionable, but that it is subject to change cannot be denied. Knits of manmade fibers and of blends of manmade fibers cannot be boiled. Cotton scores on this point at present.

[9]Courtaulds Report and Accounts, 1971-72. Alabaster Passmore & Sons Ltd., London and Maidstone 275. United Kingdom.

It is expected that more cotton will be used in double knits, either as all-cotton or cotton/manmade fiber blends, because the deluge of Jacquard double knit dresses and women's suits made of polyester texturized filament yarn has already subsided somewhat in Western Europe. Cotton could make good progress in double knit goods if manufacturing problems were overcome and "pipeline thinking," i.e., promotion of cotton knit products at all stages from yarn to fabric to garment to retail, were further developed. This approach is being used by IIC. If manufacturers and consumers were convinced of the desirability of cotton double knits, dresses, suits, and other cotton knit outerwear products, they would be made and sold, despite the present problems and the relative prices. There must also be a disposition on the part of knitters to expand their use of cotton. It has been determined that some knitters engaged in processing competing fibers simply do not care to process cotton, even if they have the technical ability to do so.

There are undeveloped possibilities in warp knits for cotton. According to one authority, warp knitting has enormous potential for production of stable cotton fabrics with controlled elasticity. In this are also included certain stitch bonded techniques based on warp knitting which have not been fully exploited.

Growth in single knits for business shirts and women's blouses and dresses will rest on the use of all-cotton yarns, polyester/cotton blended yarns, and acrylic/cotton yarns, although polyester/high wet modulus rayon blend yarns will also be used. The use of spun yarns, especially blends, which incorporate the strength and elongation of manmade fibers and the comfort and absorptiveness of cotton, are expected to be of increasing importance.

In the industrial field, cotton is strongly entrenched as a base fabric for vinyl coated fabrics for furniture and automotive use and for artificial leather for apparel and can be expected to hold this market. In Western Europe it is also used for nets for food packaging.

In the household field, cotton is challenged by nylon knit sheets mainly in the United Kingdom, although in combination with polyester, cotton in woven fabrics may regain part of the market. In 1972, cotton held about 90 percent of the sheet market in other Western European countries. Knitted cotton has little place in other household uses except dishcloths.

While the level of knit penetration of total market may stabilize at somewhat higher level than at present, it is likely that the rate of growth will be sharply lower than that shown in the chart on production of standard woven goods and knitted goods in the EEC and EFTA. To some extent, the weaving sector of textile manufacturing industry in Europe was shaken by the knit explosion. However, it is expected that weaving will remain the most important method of fabric production for many decades to come and some spokesmen expect that it may even be "given a fresh upsurge." One needs only to keep in mind the relationships shown in the second chart to understand the importance of weaving in the total scheme of textile production.

According to W. P. Schneider: "By making use of the possibilities of the weaving mill—often measured far too pessimistically—the challenge from knitgoods is quite capable of being met."[10] Schneider points out that the use of up-to-date weaving machinery, modernization, quality controls, versatility, and better finishing, all of which are presently possible, enable more capability for wovens to compete with other types of textile products.

While improvement of cotton's position in knitgoods may continue to be less than desired, the relative share of cotton in the total market could be improved by expected advances in women's apparel and household uses, and further by the development of warp knitting equipment that could handle spun yarns on an economic basis. The advance in use of stretch wovens is an example of imaginative use of weaving equipment to attain an end-use quality demanded by consumers.

Whether the forecasts of unrestrained optimism that are being made by manmade fiber manufacturers will come to pass depends in large measure on the dedication and commitment of resources with which cotton interests take up the challenge to meet the increased preferences of consumers for natural fibers.

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[10]"The Position of Weaving in an Integrated Textile Industry from the Viewpoint of the Machine Manufacturer," by W. P. Schneider, Head of the Textile Machinery Division, Sulzer Brothers, Ltd., Winterthur, Switzerland, in paper given at annual meeting of the Norwegian Textile Society, May 1970.

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